

## **SOLVE-II Flight Report: Saturday 01/04/2003**

### **Flight Type: Test Flight – Deep subtropical flight**

#### **Flight Objectives:**

1. Sun run for DIAS, AATS-14, and GAMS/LAABS in subtropics
2. 4th full test of lidars and in-situ instruments under sunlit and dark conditions.
3. Scan of tracers in the upper tropospheric sub-tropics. - Outflow from ITCZ.
4. Profiles of ozone and aerosols in the stratospheric tropics, providing contrast with mid-latitude transit profiles and polar profiles.
5. Possible measurement of El Reventador, Ecuador stratospheric volcanic plume.

#### **Flight Plan:**

21:00 - Takeoff

00:22 – Southernmost point 10°N, 115°W. Turn NNW and begin sun run

01:28 – End sun run, 16°42'N, 118°24'W. Continue northward

04:12 – Turn south at Shafter 35°39'N, 119°06'W

04:35 - Land

#### **Forecast Meteorology:**

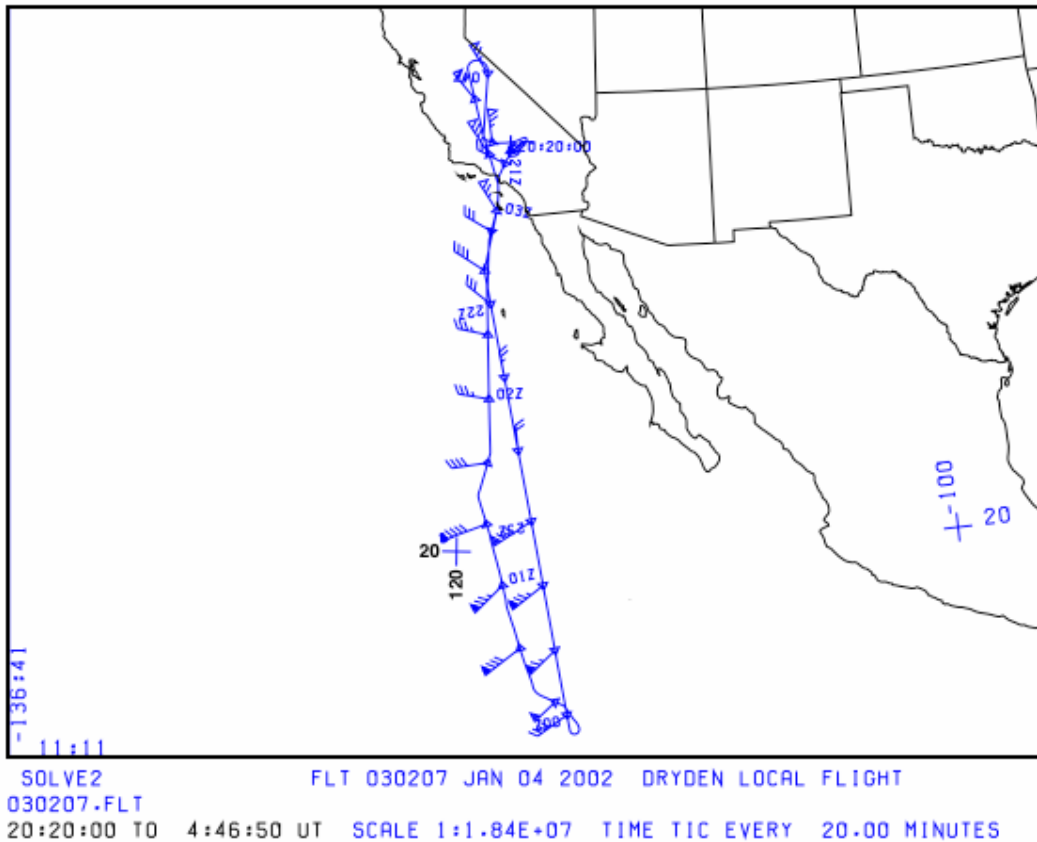
Flight track to 10°N, 115°W is just downstream of a shortwave trough digging equatorward in the upper tropospheric westerlies. Ahead of the trough, and squarely across today's southbound flight path beginning at about 20°N is a stream of moist upper tropospheric air flowing out of a region of persistent convective disturbances in the ITCZ centered near 10°N. Expect to see patches of high-level cirrus between this latitude and the southernmost point. Winds along the flight track will be range from 20-40 kts and will be out of the west south of 30°N.

The large-scale anti-cyclonic flow to the NW of today's flight is a classic example to a wave breaking event. In such events, high PV is pulled out of the mid-latitudes into the subtropics and forms a long streamer of mid-latitude air. In our case, we see the formation of the shortwave trough as this high PV is pulled into the sub-tropics. Today's flight down the axis of this trough will show a mixture of "middle-world" stratospheric and tropospheric air. Some streamers of pure tropical air will be in evidence during the flight. At the southern end of the flight, we will pass into an area that has recently been transported from the deep tropics.

Dryden WX: Mostly sunny today and clear tonight, high in upper 60 to low 70s, southwest winds 10 to 15 mph.

#### **Flight Meteorology:**

## SOLVE II flight, January 4, 2003, Southern Survey



### Flight Report:

Takeoff was about 3 minutes late (13:03 PST) because of some tests that were being performed to identify an interference problem with GAMS/LAABS. Conditions were fairly clear near the Edwards/LA area, but we immediately ran into thick cirrus after passing over the ocean (35 kft or about 330 K). Because of the high sun, we remained in the cirrus for the in-situ instruments. Winds were nominally out of the WNW at about 30 kts. Ozone was relatively low (50-60 ppbv) with respect to stratospheric values of 100-200 ppbv. By 31N, we were out of the thick cirrus, but cirrus was still evident on the horizon.

The flight southward was relatively uneventful. The air was very consistent in composition with ozone values hovering around 60 ppbv, but the air became much dryer. The preliminary H<sub>2</sub>O values were up near 70 ppmv near California, but had fallen off to about 35 ppmv near 26°N. The wind direction had also come around from about WNW near the coast, to 20-30 kts N winds at 26°N. While the winds were expected to be weaker in this region, the forecast did not show northerly winds. The tropopause was up around 16 km in this region. Again, the forecast showed very interesting tropopause structure, but is not being observed.

The winds began to pick up 40 kts WSW at about 22N on the way south (23Z), while we were still at 35 kft (340 K). H<sub>2</sub>O mixing ratios had fallen to below 15 ppmv in this area, while ozone had climbed up to about 90 ppbv.

At about 2302 or so, we entered a patch of cirrus where ozone fell off dramatically to about 40 ppbv, and water jumped to very high values. In addition, the winds came around to SW at about 90 kts (approximately twice the forecast wind speed, albeit, about the correct direction). As we continued further southward (19°N), we came into a very thick layer of cirrus. This air was most probably the very wet air that was predicted to be coming up from the south in the model.

We requested FL390, but didn't get permission for this level. DIAL estimated that the cirrus extended up to about 41 kft. By 16°N 116°W, the ozone was still low, H<sub>2</sub>O was high (~250 ppmv), and the clouds were still quite thick above us. Winds had fallen off to about 60 kts from the SW, and the tropopause was at about 14-15 km.

At about 23:50, we ascended to FL390, but were unable to clear our way out of the cirrus. The cirrus was patchy, but still extensive. Given that we would be unable to get a clear view of the sun, we opted to stop the southern portion of the flight and turn back northward. We began the turn roughly at 0Z (approximately 20 minutes early). At this southern point (~13°20'N, 115°13'W) During the turn we dipped down a few hundred feet to try and intercept our own plume, there was some enhancement of small particles, but not a clear intercept.

At the southern end, winds had fallen off to about 40 kts SW, the tropopause was well defined at 16 km. The temperatures were at about -54C at aircraft altitude, and about 180K at the tropopause.

As we continued north, the winds began to pick up once again, mirroring our southward leg. By 15°40'N, 117°14'W the winds had picked up again to 85 kts SW. We had occasional patches of clear air for the solar instruments on this northward leg, and managed to acquire some solar data, but generally had a poor time of it on this leg. By 17°N, MTP was reporting a tropopause near 190 K at 16 km.

As we continued northward at 39 kft (347 K), at about 19°N, ozone concentrations suddenly jumped up over 100 ppbv, H<sub>2</sub>O fell below 10 ppmv, and the skies became clear as far north as we could see. Wind speeds were still SW, but had weakened to about 45 kts. MTP profiles showed some development of a tropopause fold situation. Both AROVAL and DIAL showed an ozone minimum near the MTP 16 km tropopause, with higher ozone values both above and BELOW this level. The solar instruments managed to get a reasonable sun run during this stage of the flight.

Both ozone (65 ppbv) and H<sub>2</sub>O (11 ppmv) concentrations remained fairly constant up to 23°N after the high ozone values that we saw near 19°N. At 23°30'N 118°42'W, the winds had come around to W at about 37 kts.

The very optically thin El Reventador volcanic cloud was observed in the stratosphere in three narrow layers at approximately 18, 19, and 20.5 km. The layers were observed over considerable distances during the flight. At the southernmost points, the lidars were obscured by the thick cirrus.

MTP began to see a double tropopause starting at about 18N. This structure was still in evidence as we flew northward. By 26.5°N, the tropopause folding structure was very much in evidence.

The crescent moon looked fabulous during sunset today!



At approximately 02:30Z (29°30'N) we ascended to 41kft. Ozone immediately jumped to over 200 ppbv. The MTP profile showed a dramatic change in structure, suggesting that we were immediately beneath a stratospheric layer of air. Water vapor from DLH fell to about 5-6 ppmv.

As we continued northward, the double tropopause remained in evidence. At 02:45, we descended back to FL390 as per ATC instructions. As we descended, water increase and ozone decreased, but shortly after returning to 390, ozone increased to levels above 200 ppbv and water also decreased to about 7 ppmv. These changes suggest the FL390 is immediately below a layer of stratospheric air.

Both DIAL and AROTAL showed the El Reventador cloud to be more optically dense and coalesced into a layer just above 20 km. Still good evidence for the plume to 35N. At 03:10 UT we ascended back to 41 kft. MTP now showed a really dramatic double tropopause with one of the minimum immediately below the aircraft slightly below 12 km, with the 2<sup>nd</sup> temperature minimum near 18 km. AROTAL showed a similar minimum closer to 16 km. The thermal lapse rate suggested stratospheric air, which was confirmed by the high ozone and low water vapor.

At the northern end of the flight (roughly 38N), winds were out of the NW at about 60 kts (41 kft, 340K). MTP continued to show the double tropopause.

Shortly after the turn, DIAPER reported multiple plume hits. Winds from the NW at 60 kts suggest this was probably our own plume.

Began descent at 04:16Z.

Pilots: Bomben and Batteas

Navigator: Kevin Hall

Mission managers: Chris Miller

Mission scientist on board: Paul A. Newman.

### **Status Report: Instrument – PI**

DIAPER (in situ aerosols) – Anderson

Good day, everything worked.

FastOz – Owens

Great flight, took nice measurements. Ready to go to Sweden.

DIAL (Lidar ozone and aerosol above and below the AC) – Browell

Reasonably good flight. Some problem with cirrus. Instrument worked well.

DACOM/DLH (in situ trace gases and open path water vapor) – Diskin

With the exception of N<sub>2</sub>O, everything worked really well.

PANTHER (in situ PAN and other trace gases) – Elkins

Had data for about 2/3's of flight on the ECDs and mass spec.

Subsequently found that a pump valve had broken, and the data was compromised.

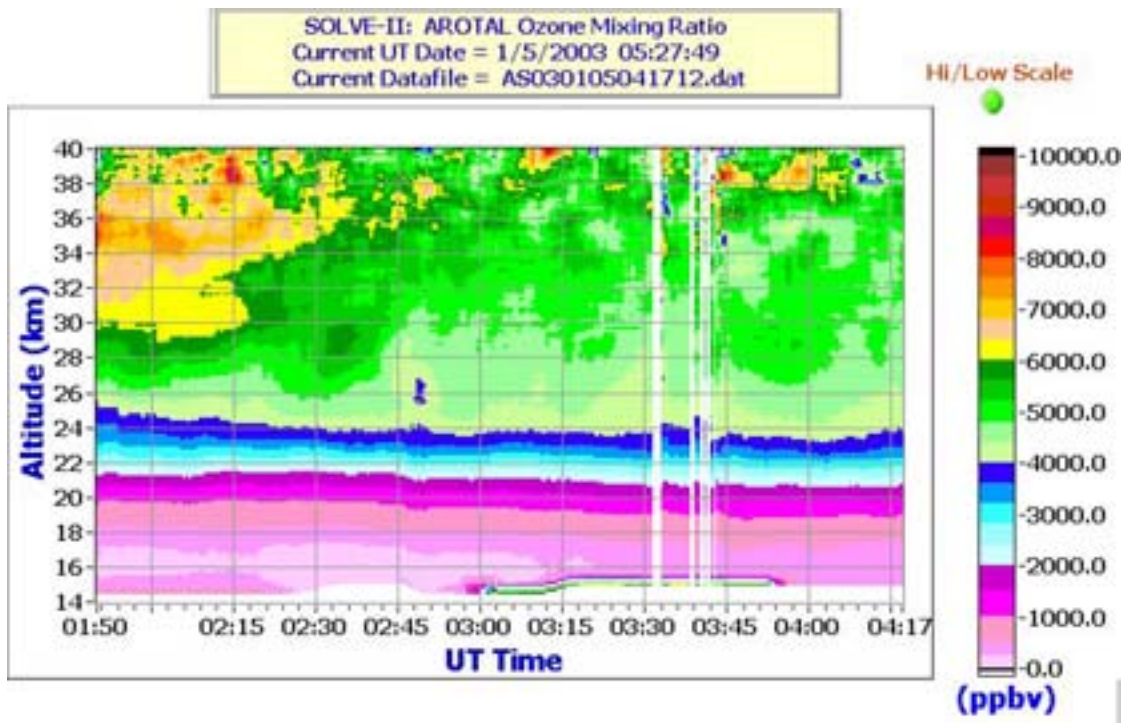
MTP (microwave temperature profiler) – Mahoney

Great flight. T below 180K, double structure, some mid-latitude air.

AROTAL (Lidar ozone, aerosols and temperature above the AC) - McGee/Hostetler

McGee - Pretty good flight. Some really good data coming back north from the southern leg.

Hostetler – Really good flight.



Ozone curtain file following the flight of 030104 from AROTAL. The latitude ranged from approximately 20°N at 01:50 on the left to about 35°N at 04:00 on the right. Note the decrease of ozone at the upper altitudes as we flew from subtropical air towards the mid-latitudes.

GAMS/LAABS (solar occultation ozone, aerosols and oxygen A band) – Pitts  
Good trouble shooting session. Couldn't find a source of electrical noise.

DIAS (Direct beam solar irradiance) – Shetter  
Great flight as soon as the sun came up.

FCAS/NMAS (in situ aerosols) – Reeves  
Pretty good flight. Erroneous fail light on NMASS.

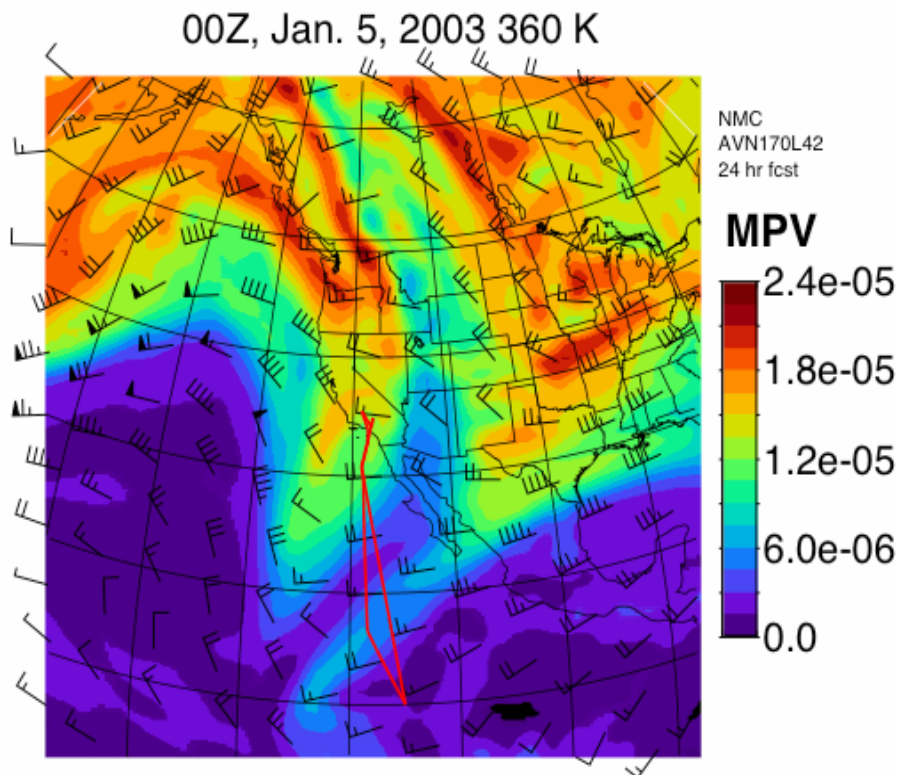
AATS-14 (sun photometer) – Russell  
Good day. A bit of a temperature control problem. Interesting data, decrease of optical depth of factor of 3 to 4. Good sun run.

Differential GPS – Muellerschoen  
1 of 2 GPS not working.

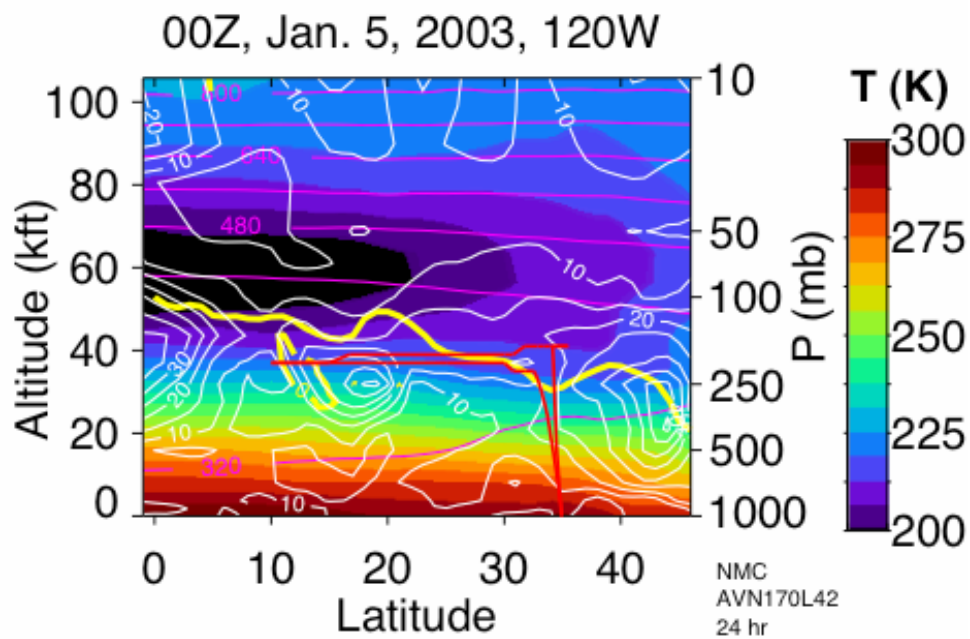
ICATS  
Good flight.

**Plots (flight plan, solar zenith angles, Rel. humidity):**

Flight Plan:

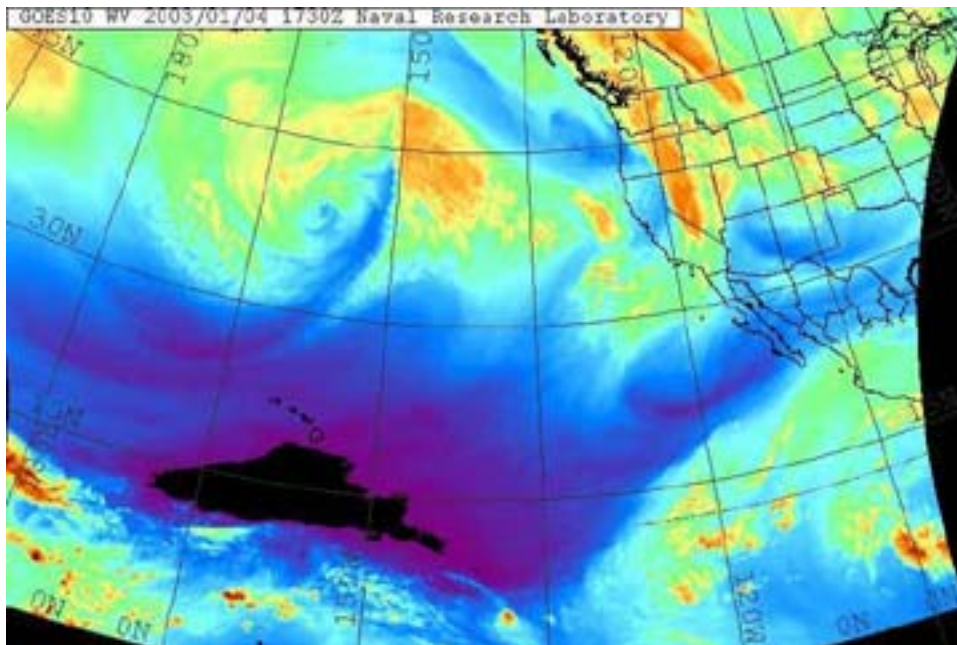


Forecast horizontal transect along 120°W 24 hr forecast.



Water Vapor image at 1730UT on January 4, 2003 at 1730Z.





RH at FL390 from the NCEP AVN 24 hr forecast.

00Z, Jan. 5, 2003 360 K

